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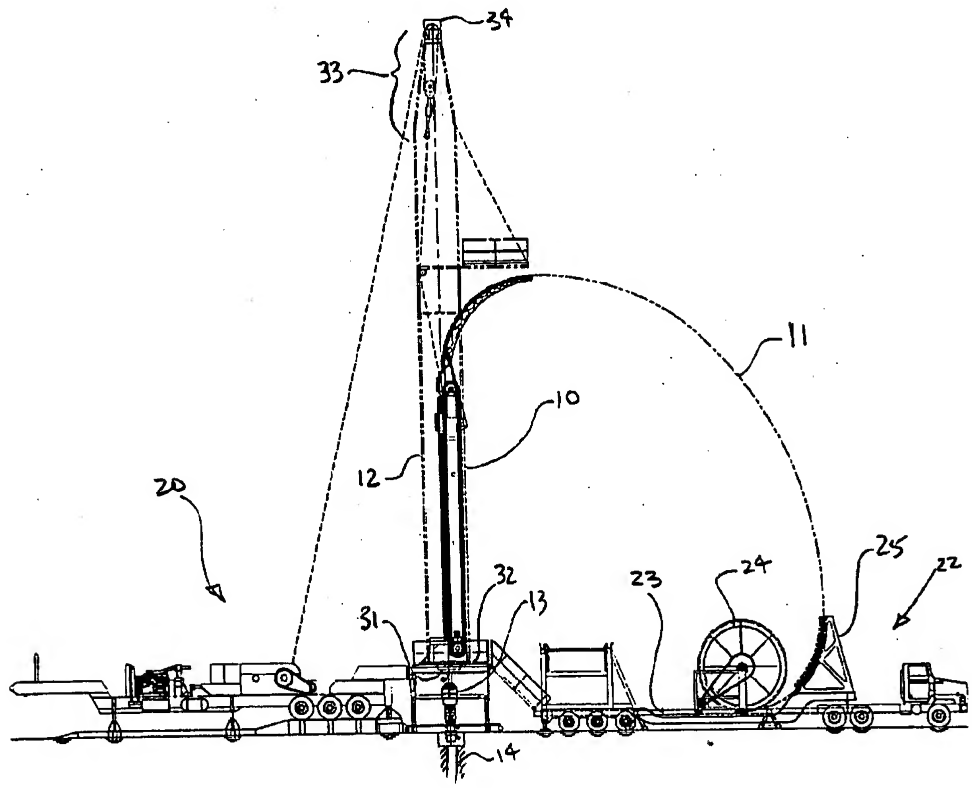


(57) Abrégé/Abstract:
An injector is provided for injecting and withdrawing large diameter coiled tubing comprising a linear section of gripping blocks driven on an endless chain conveyor. The coiled tubing is forced into frictional engagement with the blocks by a corresponding linear array of rollers. The injector is not restricted in length and thus provides a linear driving section of configurable length for providing superior injection and pulling capacities. In combination with the strong draw works, derrick and rotary table of a conventional rig enable making up both sectional tubing for assembling BHA's, drilling surface hole and making up to non-rotating coiled tubing from the injector.

"LINEAR COILED TUBING INJECTOR"

FIELD OF THE INVENTION

The invention relates to apparatus for injecting coiled tubing, and more particularly to an injector having a long, linear tubing gripping section formed of a linearly extending portion of endless conveyor of grooved blocks and substantially continuous opposing rollers.

BACKGROUND OF THE INVENTION

The general background relating to coiled tubing injector units is described in U.S. Patent No. 5,839,514 and 4,673,035 to Gipson which are incorporated herein by reference for all purposes.

Coiled tubing has been a useful apparatus in oil field operations due to the speed at which a tool can be run in (injected) and tripped out (withdrawn) from a well bore. Coiled tubing is supplied on a spool. An injector at the wellhead is used to grip and control the tubing for controlled injection and withdrawal at the well. As coil tubing cannot be rotated, drilling with coiled tubing is accomplished with downhole motors driven by fluid pumped downhole from surface.

As stated, coiled tubing has more recently become a contender in the drilling industry, due to the potential to significantly speed drilling and reduce drilling costs through the use of continuous tubing. The most significant cost saving factors include the reduced pipe handling time, reduced pipe joint makeup time, and reduced leakage risks.

In spite of the significant potential cost savings through the use of coiled tubing, the injector has limited its application to deeper wells.

Coiled tubing has been used primarily on shallow wells. One reason is due to the low tubing string pulling strength of many conventional coiled tubing injectors as compared to the draw works provided with conventional jointed tubing derricks. Further, a conventional wellhead injector tends to inject tubing which has a residual bend therein. As one can imagine, a residual bend results in added contact and unnecessary forces on the walls of the drilled hole or casing, increasing frictional drag and causing an offset positioning of the tubing within the hole. Occasionally the coiled tubing can wad up in the hole (like pushing a resilient rope through a tube) and cannot be injected any further downhole or ever actually reach total depth.

As described in US Patent 5,842,530 to Smith et al. (Smith), apparatus is disclosed which is directed to providing a single rig having both conventional and coiled tubing capability. Smith describes how jointed tubing is used during the vertical, and substantially linear, drilling and switching to non-rotation tubing and downhole motors after deviating the well to the horizontal. However, by combining the two technologies in a single rig, Smith's mast is limited in its crown and draw works capacity. Further, Smith discloses the use of a conventional injector.

A conventional injector comprises two continuous, parallel and opposing conveyors having grooved shoes or blocks mounted thereon such as that disclosed in US Patent 5,533,668 to Council et al. for Halliburton Company,

Oklahoma. The opposing conveyors have facing portions where the multiplicity of gripping blocks run parallel for gripping the tubing therebetween, typically positioned inline, directly adjacent and above the wellhead.

One characteristic of the dual conveyor injectors is that the facing grooved blocks must have absolutely synchronous timing and engagement with the coiled tubing, the failure to do so being associated with damage to the coiled tubing. Damage to the coiled tubing further reduces the lifespan of tubing already suffering a short lifespan due to reversing stresses inherent in the technique.

In US Patent 5,839,514 to Gipson, an improved injector comprises a grooved reel and hold-down rollers for imparting the gripping force necessary to drive the coiled tubing. This reel type injector, while causing less damage to the tubing than the block type is limited in pull capability, in part due to the short tubing gripping length. The gripping length of reel-type coiled tubing drives is limited by the circumference of the reel; the maximum circumference being limited to less than 360 degrees due to the inability to permit overlap tubing wrapped around a grooved driving reel.

Deeper wells can be accessed, for either workover or drilling purposes if the pull strength can be increased. Further, deeper wells usually require larger diameter tubing to handle greater string weight and to minimize fluid pumping power requirements. As the fluid for driving mud motors is delivered down the bore of tubing, fluid friction causes significant pressure drop and thus require large power sources at the pumps. The larger the tubing, the lower the fluid friction losses and the lower the power requirements.

Rigs utilizing either the dual conveyor or the reel type injectors have had difficulty in dealing with larger diameter tubing. Further, while the use of coiled tubing has provided for faster operation to depth and out again, the equipment has a higher capital and operating cost. For example, coiled tubing rigs use more complicated and expensive equipment, have higher power requirements for pumps and the like and the repeatedly deformed coiled tubing has a limited life and must be periodically replaced with new coiled tubing.

Further, coiled tubing apparatus is typically provided on a single transportable rig which provides a spool of coiled tubing, an injector and its own mast which is designed for light or small diameter coiled tubing, portability and generally low pull weight. The mast and rigs generally are not suitable for work with deeper wells.

SUMMARY OF THE INVENTION

The linear injector of the present invention extends coiled tubing capability beyond that known heretofore. In combination with a conventional joint d drilling rig, none of the functionality of the conventional rig is sacrificed while achieving enhanced capabilities by the addition of coiled tubing.

With the preferred embodiment, coiled tubing is driven along a linear section of an endless chain conveyor with an opposing linear array of rollers. With prior art dual conveyors, gripper blocks pull on both sides of coiled tubing and the present invention only pulls on one side. Thus, while the invention's pulling capability per lineal length of tubing capability is seemingly halved as compared to prior art injectors, applicant has found that by eliminating the prior art parallel chain drives, the difficulty to synchronize the two drives is avoided and the substitution of non-driving rollers for one side of the tubing injector results in less damage to the coiled tubing. Further, by eliminating the challenge of maintaining dual chain synchronicity, the novel injector is able to take unrestricted advantage of an extended length of a linear driving section, thus providing superior injection and pulling capability.

Accordingly, in one preferred aspect of the invention, deep wells can be drilled with coiled tubing even from the surface due to the combination of enabling the use of full diameter tubing, implementing a straightener and using an injector which is capable of applying both significant injector force on a drilling bit and full pulling capability for tripping out of the deep wells. An injector of 20 feet in length is capable of a nominal pulling capacity of about 100,000 lb. force. Further,

suspension of the preferred injector in a conventional derrick having strong draw works and a rotary table permits operation with both conventional sectional tubing, including BHA, and simplifying the making up to coiled tubing.

In a broad aspect of the invention then, coiled tubing injection apparatus is provided comprising:

- a chain conveyor extending about an endless path and having at least one linear section aligned with the wellbore;
- a multiplicity of gripper blocks conveyed and driven by the chain conveyor, the gripper blocks forming a substantially continuous coiled tubing support while traversing the linear portion;
- a linear array of a multiplicity of rollers in parallel and opposing arrangement to the linear section of the chain conveyor for forming a corridor therebetween and through which the coiled tubing extends, the rollers urging the coiled tubing into frictional engagement with the gripper blocks;
- means for supporting the gripper blocks against the normal forces produced by the linear array of rollers; and
- means for driving the chain conveyor along the endless path so as to drive the gripper blocks which frictionally drive the coiled tubing along the corridor.

Preferably a tubing straightener is positioned between the apparatus and a source of coiled tubing, just preceding the corridor between the linear portion

of the gripper blocks and the linear array of rollers. Jacking means are provided for adjusting the normal force imposed by the rollers against the coiled tubing.

In another embodiment, the linear injector can be pivotally mounted to a mobile transport for aligning the linear injector with wellheads at any angle to the surface.

Further, in another embodiment, apparatus for injecting and withdrawing coiled tubing into and out of a well comprises combining the above linear coiled tubing injector suspended it in the derrick of a conventional drilling rig positioned over the well. Preferably the injector is movable between a first position aligned with the well for injecting and withdrawing coiled tubing and a second position out of alignment so that the derrick can trip in and out sectional tubing from the well. More preferably, a rotary table in the conventional rig is used to make up connections, in the second position between sectional tubing and in the first position between sectional tubing and the coiled tubing.

The apparatus enables the practice of a novel process for injecting and withdrawing coiled tubing from a well comprising: providing a conventional derrick positioned over the well; suspending a coiled tubing injector in the derrick for driving the coiled tubing, the injector having a bottom end secured adjacent the well, the injector having a linear coiled tubing drive corridor extending between bottom end and a top end of the injector, the corridor being aligned with the well; and straightening the coiled tubing before it enters the injector.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1a is a side elevation view of one arrangement of the novel linear injector in combination with a conventional jointed tubing derrick and draw works. For convenience, the coiled tubing transport rig is illustrated aligned with the rig for the conventional derrick;

Figure 1b is a plan view of the arrangement according to Fig. 1a illustrating a preferred out of alignment arrangement of the coiled tubing transport rig and the conventional derrick;

Figure 2 is a side elevation view of the linear injector arrangement according to Fig. 1a, the linear injector being in a shipping position on its coiled tubing trailer;

Figure 3 is a side elevation view of the linear injector arrangement according to Fig. 1a, the lower end of the linear injector being pinned conventional derrick and the upper end being in a partially raised position as lifted by the derrick's draw works;

Figure 4 is a partial side view of the linear injector of Fig. 1a installed in the conventional derrick and aligned over the wellhead;

Figure 5 is a partial close up side view of the linear injector of Fig. 4 illustrating the straightener and nip of the blocks and the rollers;

Figure 6 is a plan, cross-sectional view of one embodiment of the head sprocket and drive for illustrating the a hydraulic arrangement for loading the rollers which force coiled tubing into frictional contact with the blocks;

Figure 7 illustrates a cross sectional view of on embodiment of a manual arrangement for loading the rollers against the coiled tubing using a Belleville washer feedback system;

Figures 8a – 8c illustrate isometric, side and end views respectively of one embodiment of the gripper block assembly, wherein conventional roller chain is fitted with gripper blocks;

Figure 9 is an isometric view of an alternate embodiment of gripper block, specifically illustrating a single offset roller gripper block;

Figure 10 is an isometric view of a train of offset roller gripper blocks according to Fig. 9, one of which is shown fitted with an idler;

Figure 11 is an isometric view of an alternate embodiment of gripper block, specifically illustrating the narrow block of a matched pair of roller gripper blocks;

Figure 12 is an isometric view of the wider second block of a matched pair of roller gripper blocks according to Fig. 11;

Figure 13 is an isometric view of the wider second block of Fig. 12 fitted with idlers;

Figure 14 is an isometric view of a train of roller gripper blocks according to Figs. 11 and 12 extending over a sprocket; and

Figure 15 illustrates a side elevation view of an alternate implementation of the novel linear injector, illustrating three stages (a),(b),(c) of an all-in-one coiled tubing rig utilizing the novel injector for workovers or for directional drilling of predominately shallow wells.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Having reference to Fig. 1a, a new injector 10 for coiled tubing 11 is provided. Use of the new injector 10, in combination with a suitable support or derrick 12 can utilize straightened, full diameter tubing at the wellhead 13, now truly providing substantially all the advantages of both conventional jointed drill tubing and coiled tubing.

More particularly, a conventional jointed tubing drilling rig (conventional rig) 20 is positioned at a well 14. A novel coiled tubing transport rig 22, according to the present invention, is also positioned at the well 14. For reasons elucidated in greater detail later, the preferred coiled tubing rig 22 incorporates only means for transporting the novel injector 10 and does not include pumps and the like, and thus is substantially less complicated and less expensive than prior art coiled tubing injector rigs.

More particularly, the transport rig 22 comprises a mobile trailer or truck frame 23 having a coiled tubing spool 24 mounted thereon. Conventional means (not detailed) are provided for managing coiled tubing dispensing and retrieving, such as a tubing traversing mechanism and spool drives. A curved guide 25 is provided for directing the coiled tubing 11 approximately along a parabolic loop.

Best shown in Fig. 2, the transport rig 22 forms a transport bed 26 for storing and transporting the linear injector 10 to the well 14. Once at the well, rather than utilizing the transport rig 22 to support the linear injector 10, it is mounted and supported in the conventional rig 12.

As illustrated, the conventional rig 20 may comprise a mobile trailer 30, the derrick 12 rising from the rotary table 31 at the drilling floor 32 to the draw works 33 in the crown 34 and means for mounting the linear injector 10 in the derrick 12.

As shown in plan in Fig. 1b, the transport rig 22 and conventional rig 20 are oriented out of alignment for retaining full functionally of the conventional rig 20. Accordingly, a catwalk 35 and pipe rack 36 are able to access the drilling floor 32. Further, mud pumps 37 and mud tanks 38 accompany the conventional rig 20.

More particularly, the linear injector 10 is a continuous conveyor 40 having an upper 41 and a lower end 42. As shown in Figs. 2 and 3, the lower end 42 of the linear injector 11 is rotationally pinned in the derrick 12 above the drilling floor 32. The linear injector 11 is hoisted into the derrick 12. As shown in Fig. 3, a cable 29 from the derrick's draw works 33 is directed about an idler 39 located about the monkeyboard and is attached to the upper end 41 of the linear injector 10.

Using the draw works 33 and cable 29, the upper end 41 is hoisted upwardly, pivoting the linear injector 11 about the bottom end 42 and into position. The linear injector 11 is aligned in the derrick 12 and in-line with the well 14. The linear injector 10 is secured for suspending it in the derrick 12.

The linear injector 11 can be alternated between two positions within the derrick. In a first position, the linear injector is inline with the wellhead 13 for injection and withdrawal of coiled tubing 11. In a second position, the linear injector 10 is shifted or set aside in the derrick 12 to take the injector out of alignment from the well 14. When out of alignment, the derrick 12 can be used in a conventional

manner; more specifically to enable sectional tubing to be pulled up the catwalk 35 and into the derrick 12 and utilizing the rotary table 31 for making up threaded joints.

Having reference to Fig. 4, the linear injector 10 comprises this rigid and continuous chain conveyor 40, which when secured in the derrick has its lower end adjacent the drilling floor 32 and a chain 43 extending about an endless and reversible path 44 therearound. The upper end 41 of the continuous conveyor 40 is fitted with a gooseneck 46 for guiding the coiled tubing 11.

Best shown in Fig. 5, the continuous conveyor 40 is fitted with upper and lower drive sprockets 47,48. The endless chain 43 is fitted with a multiplicity of coiled tubing gripper blocks 50; one block 50 per link of the chain 43. The blocks 50 move with the chain conveyor 40. The moving gripper blocks 50 are formed with grooves 66 to accept the coiled tubing 11.

The continuous conveyor 40 provides a long linear section 49. A linear array of complementary hold-down rollers 51 exert a normal force on the coiled tubing, urging it into the moving gripper blocks 50 and thereby frictionally engaging the coiled tubing 11 with minimal damage caused thereto. The long length of the linear section 49, coupled with the even coiled tubing gripping force imposes large pulling force on the coiled tubing 11, resulting in significant pulling capability. The long linear section 49 also accommodates long rigid sectional strings. As a result, the linear injector 11 can be used in a variety of heretofore restricted applications including the injection of long strings of downhole tools or in

the case of drilling operations, injecting and pulling out large bore coiled tubing 11 in deep well drilling operations.

The length of the linear section 49 is configurable depending upon the driving force required, but is usually maximized, limited typically by the working height within the derrick 12. For instance with a working height of about 50 – 60 feet normally provided for making up stands of jointed tubing, the linear section of the injector 11 may be about 30 feet tall. A straightener 52 and a coiled tubing guide gooseneck 53 must also be accommodated in the derrick 12.

In more detail, and referring to Figs. 5 and 7, the linear array of hold-down rollers 51 comprises a multiplicity of these rollers, distributed along, parallel to and facing the linear section 49 of gripper blocks 50. The rollers 51 are similarly grooved to accept coiled tubing 11. A corridor 60 is formed between the opposing grooves of the gripper blocks 50 and rollers 51. The coiled tubing 11 extends through the corridor 60.

The moving gripper blocks 50 are movably supported by skate or track means 61, located along the linear section 49, so as to resist the force produced by the rollers 51 and thereby grip the coiled tubing 11 therebetween.

In one embodiment shown in Figs. 8a-8c, the gripper blocks 50 are provided as a separate component 63, mounted to brackets 64 on roller chain 43a. The entire linear section 49 of the continuous conveyor 40 is supported along its linear section by a linear skate 61a, backing the roller chain 43 of the conveyor 40.

In another more preferred embodiment shown in Figs. 9 and 10, the moving gripper blocks 50 themselves (roller gripper blocks 65) form the continuous

chain conveyor 40. Each roller gripper block 65 comprises a block 50 formed with a semi-circular groove 66, fitted with a replaceable insert 67 which is sized to match the diameter of the coiled tubing 11 being used. The roller gripper blocks 65 have an offset link configuration having narrow first bifurcated prongs 68 and second wider bifurcated prongs 69. Adjacent blocks 65 interconnect with the first prongs 68 fitting between the wider second prongs 69 of the immediately adjacent block 50 with pin 70 pivotally connecting them together.

In another embodiment shown in Figs. 11 – 14, again the moving gripper blocks 50 themselves form the continuous chain conveyor 40 and are fitted with the grooves 66 and inserts 67. In this embodiment, two types of roller blocks are provided; one block 75a having closely spaced links 76a and another block 75b with widely spaced links 76b. Each roller block 75a,75b is mounted to (or formed with) a pair of parallel links 76a,76b, spaced sufficiently to enable the upper and lower sprockets 47,48 to pass therebetween (Fig. 14). As shown in Fig. 13, the roller pin 70, as per the previous embodiment, passes transversely through the links for pivotally pinning them together.

Having reference to Fig. 14, the narrow spaced links 76a fit between the widely spaced links 76b, the narrow and widely spaced link roller blocks 75a,75b connected in alternating fashion and, when pinned together, form the continuous chain conveyor 40, shown wrapped about a sprocket 47,48.

The interconnecting pins 70 of any block 50 or specific configuration 65,75a,75b are engaged by the upper and lower drive sprockets 47,48. As shown in Figs 10,13,14 and 5, the transverse or distal end of each pin 70 supports a

bearing 80. The bearing 80 forms a hub for a larger diameter roller (not shown) which engages a backing track 61b, replacing the skate 61a of the earlier embodiment and enabling the blocks 50 to resist the normal force imposed by the rollers 51.

The chain conveyor 40 is driven at one or both of the upper and lower sprockets 47,48 preferably using hydraulic motors or planetary drives 85. The drives 85 are reversible for providing injection force in the CCW direction and pulling force in the CW (rotation referenced to Fig. 4). The pitch of the conveyor chain 43 is minimized to reduce the diameter of the upper and lower sprockets 47,48, resulting in a reduced driving moment and reduced drive size.

Referring to Fig. 7, in an example of the simplest embodiment, the rollers 51 are set using adjusting or jacking bolts 90 for exerting a fixed and consistent force for the size of coiled tubing 11 used. Conical spring or load-indicating washers 91, such as Belleville washers, are used to set the jacking bolts 90 to the appropriate roller load to maximize normal force without damaging the coiled tubing 11. Other elastomeric load-indicating washers (not shown) may also be used.

Referring once again to Figs. 4 and 5, a tubing straightener 100 is located at the upper end 41 of the linear injector 10 so that coiled tubing 11, without appreciable residual bend, is caused to enter the injector 10, reducing load on the gripper blocks 50 and rollers 51 and further so that coiled tubing leaves the linear injector straight. When pulling the coiled tubing 11 back up, the straightener re-

bends the tubing to the lowest stress possible unsupported shape – preferably a parabolic shape.

By combining a conventional derrick 12 with coiled tubing capability, a high capacity draw works 33 and a rotary table 31 is now available. Further, the physical distance placed between the conventional rig 20and the source of the coiled tubing (the spool 24) enables the formation of a large radius parabolic loop allowing the injector rig to utilize large coiled tubing diameters, including 3.5 inch typical for use in conventional rigs. The long linear injector 10 is capable of dealing with large linear lengths 49 of coiled or jointed tubing. The large fluid bore of 3.5 inch tubing reduces fluid friction pumping power requirements from about 1000 HP to only 5-600 HP at 5,000 feet. It is postulated that a 5,000 foot deep well can be drilled in about ½ the time due to the elimination of the need to make up joints every 30 feet.

The ability to use large bore 3.5", straightened coiled tubing better mimics, as close as possible, operation with conventional jointed tubing; now providing: a large pulling capability needed for deep drilling; providing straight tubing with weight on bit control suitable for controlled drilling immediately; and even for drilling surface hole. Further, the aforementioned problems associated with residual bend can be avoided.

It has been determined that a 20 foot long linear section 49 provides pull capability on 3.5 inch tubing of about a maximum of 150,000 pounds, but if oil contaminated (soaked wet), this capability can drop to about 50,000 pounds. In practice, the capability would be in excess of 100,000 lbs.

Further, it is also known that Bottom Hole Assemblies (BHA) containing the bit, mud motor and measurement equipment must be made up and can be in the order of 30 feet in length. Conventional coil d drilling units have tried various means to make up the BHA, requiring the various pieces to be threaded together. This is usually a labor intensive job because coiled tubing units are not normally set up to rotate tubing to make up the joints. Also, occasionally drill collars are threaded onto the BHA to provide startup drilling weight or improve linear stability.

Further, by combining a conventional derrick 12 with the linear injector 10, the capital costs of the whole operation are reduced. The rig 22 transporting a linear injector need not have a mast, nor fluid pumping equipment and can simply include the coiled tubing injector 10 and spool 24. The conventional derrick 12 provides the capability of lifting at the required high pull forces and through the use of the rotary table 31 enables readily making up BHA and connections onto the non-rotating coiled tubing 11.

Optionally, and referring to Fig. 6, in advanced embodiments, the force produced by the roller 51 can be dynamically adjusted using hydraulic actuators 110, further enabling the rollers 51 to adjust the normal gripping force or optionally to temporarily and sequentially lift the rollers 51 off the coiled or jointed tubing 11 to pass an upset or other diameter variation. For maintenance and adjustability, the rollers 51 can be grouped in linear arrays 111 (Fig. 5), each having several rollers 51 (e.g. five) minimizing the number of actuators 110.

In yet another application, as shown in Fig. 15, the linear injector 10, applied without a conventional derrick, is particularly well suited for shallow directional drilling or the insertion of downhole tools such as pumps or for workovers, and is able to provide continuous, straightened tubing into any well, including a slant wellhead. Without the need for a rotary table or strong draw works, the linear injector 10 can be located on its own trailer 22 and does not require further mast superstructure. As shown in Fig. 15, the linear injector 10 can be transported prone (stage (a)), raised partially for injection through a slat wellhead 13 (stage (b)) or raised completely for injection down a vertical well (stage (c)). A BHA for directional drilling or a pump can be pre-assembled and carried on an integrated coiled tubing injector rig for injection without additional equipment.

THE EMBODIMENTS OF THE INVENTION FOR WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMS ARE DEFINED AS FOLLOWS:

1. Apparatus for injecting coiled tubing into a wellbore from a source and withdrawing same comprising:

(a) a chain conveyor extending about an endless path and having at least one linear section aligned with the wellbore;

(b) a multiplicity of gripper blocks conveyed and driven by the chain conveyor, the gripper blocks forming a substantially continuous coiled tubing support while traversing the linear section;

(c) a linear array of a multiplicity of rollers in parallel and opposing arrangement to the linear section of the chain conveyor for forming a corridor therebetween and through which the coiled tubing extends, the rollers urging the coiled tubing into frictional engagement with the gripper blocks;

(d) means for supporting the gripper blocks against the normal forces produced by the linear array of rollers; and

(e) means for driving the chain conveyor along the endless path so as to drive the gripper blocks which frictionally drive the coiled tubing along the corridor to inject or withdraw coiled tubing.

2. The apparatus of claim 1 further comprising a tubing straightener positioned between the apparatus and the coiled tubing source.

3. The apparatus of claim 2 wherein the straightener is further positioned just preceding the corridor between the linear portion of the gripper blocks and the linear array of rollers.

4. The apparatus of claim 3 further comprising jacking means for adjusting the normal force imposed by the rollers against the coiled tubing.

5. The apparatus of claim 4 further comprising:

(a) a head sprocket over which the chain conveyor extends; and

(b) a tail sprocket over which the chain conveyor extends so that the linear portion of the chain conveyor is formed along a line substantially tangent between the head and tail sprockets.

6. The apparatus of claim 5 wherein the driving means comprises one or more drives which rotate one or both of the head or tail sprockets.

7. The apparatus of claim 6 wherein the means for supporting the linear section of the chain conveyor against normal forces comprises a continuous track positioned on the opposing side of the chain conveyor from the gripper blocks.

8. The apparatus of claim 7 wherein the means for supporting the linear section of the chain conveyor against normal forces comprises at least one pair of idlers extending from each gripper block, the idlers engaging and rolling along the continuous track.

9. In combination, apparatus for injecting and withdrawing coiled tubing into and out of a well comprising:

(a) a conventional drilling rig having a derrick positioned over the well; and

(b) a coiled tubing injector suspended in the derrick and having a bottom end secured adjacent the well, the injector forming a linear coiled tubing drive corridor between bottom end and a top end of the injector, the corridor being aligned with the well.

10. The combination of claim 9 further wherein:

(a) the conventional drilling rig further comprises means for handling sectional tubing; and

(b) the coiled tubing injector is movable between a first position aligned with the well for injecting and withdrawing coiled tubing and a second position out of alignment so that the derrick can trip in and out the sectional tubing from the well.

11. The combination of claim 9 further wherein the conventional drilling rig further comprises a rotary table so that rotary table is used to make up connections, in the second position between sectional tubing and in the first position between sectional tubing and the coiled tubing.

12. The combination of claim 11 further comprising a coiled tubing guide gooseneck at the top end of the injector.

13. The combination of claim 12 further comprising a straightener between the top end of the injector and the gooseneck.

14. The combination of claim 13 wherein the height of the injector's linear corridor is maximized for the height of the derrick.

15. The combination of claim 14 wherein the injector is transported to the well separately from the derrick.

16. The combination of claim 15 wherein the derrick has draw works for lifting the injector into the derrick for suspension therein.

17. The combination of claim 9 wherein the injector comprises

(a) a chain conveyor extending about an endless path and having at least one linear section aligned with the well;

(b) a multiplicity of gripper blocks conveyed and driven by the chain conveyor, the gripper blocks forming a substantially continuous coiled tubing support while traversing the linear section;

(c) a linear array of a multiplicity of rollers in parallel and opposing arrangement to the linear section of the chain conveyor for forming a corridor therebetween and through which the coiled tubing extends, the rollers urging the coiled tubing into frictional engagement with the gripper blocks;

(d) means for supporting the gripper blocks against the normal forces produced by the linear array of rollers; and

(e) means for driving the chain conveyor along the endless path so as to drive the gripper blocks which frictionally drive the coiled tubing along the corridor.

18. A process for injecting and withdrawing coiled tubing from a well comprising:

(a) providing a conventional derrick positioned over the well;

(b) suspending a coiled tubing injector in the derrick for driving the coiled tubing, the injector having a bottom end secured adjacent the well, the injector having a linear coiled tubing drive corridor extending between bottom end and a top end of the injector, the corridor being aligned with the well; and

(c) straightening the coiled tubing before it enters the injector.

19. The process as recited in claim 18 wherein the length of the corridor is maximized in the derrick for maximizing coiled tubing driving capability.

20. The process as recited in claim 19 wherein the coiled tubing driving force is maximized comprising the steps of;

(a) providing, in opposing relation, a multiplicity of gripper blocks and a multiplicity of rollers for forming the coiled tubing corridor therebetween;

(b) endlessly conveying the gripper blocks along the linear corridor; and

(c) jacking the rollers against the coiled tubing for urging the coiled tubing into frictional and driving engagement with the gripper blocks,

21. The process as recited in claim 19 wherein a downhole motor and bit are fitted to the coiled tubing for drilling the well.

22. The process as recited in claim 21 further comprising:

(a) drilling at least a portion of the well with jointed tubing using the derrick; and

(b) drilling at least a portion of the well using the coiled tubing.

23. Apparatus for injecting coiled tubing into a wellbore from a source and withdrawing same comprising:

(a) a mobile frame; and

(b) an injector mounted pivotally upon the frame so that the injector can be aligned with the well and wherein the injector comprises,

i) a chain conveyor extending about an endless path and having at least one linear section,

ii) a multiplicity of gripper blocks conveyed and driven by the chain conveyor, the gripper blocks forming a substantially continuous coiled tubing support while traversing the linear section,

iii) a linear array of a multiplicity of rollers in parallel and opposing arrangement to the linear section of the chain conveyor for forming a corridor therebetween and through which the coiled tubing extends, the rollers urging the coiled tubing into frictional engagement with the gripper blocks,

iv) means for supporting the gripper blocks against the normal forces produced by the linear array of rollers, and

v) means for driving the chain conveyor along the endless path so as to drive the gripper blocks which frictionally drive the coiled tubing along the corridor to inject or withdraw coiled tubing.

"LINEAR COILED TUBING INJECTOR"

ABSTRACT OF THE INVENTION

An injector is provided for injecting and withdrawing large diameter coiled tubing comprising a linear section of gripping blocks driven on an endless chain conveyor. The coiled tubing is forced into frictional engagement with the blocks by a corresponding linear array of rollers. The injector is not restricted in length and thus provides a linear driving section of configurable length for providing superior injection and pulling capacities. In combination with the strong draw works, derrick and rotary table of a conventional rig enable making up both sectional tubing for assembling BHA's, drilling surface hole and making up to non-rotating coiled tubing from the injector.

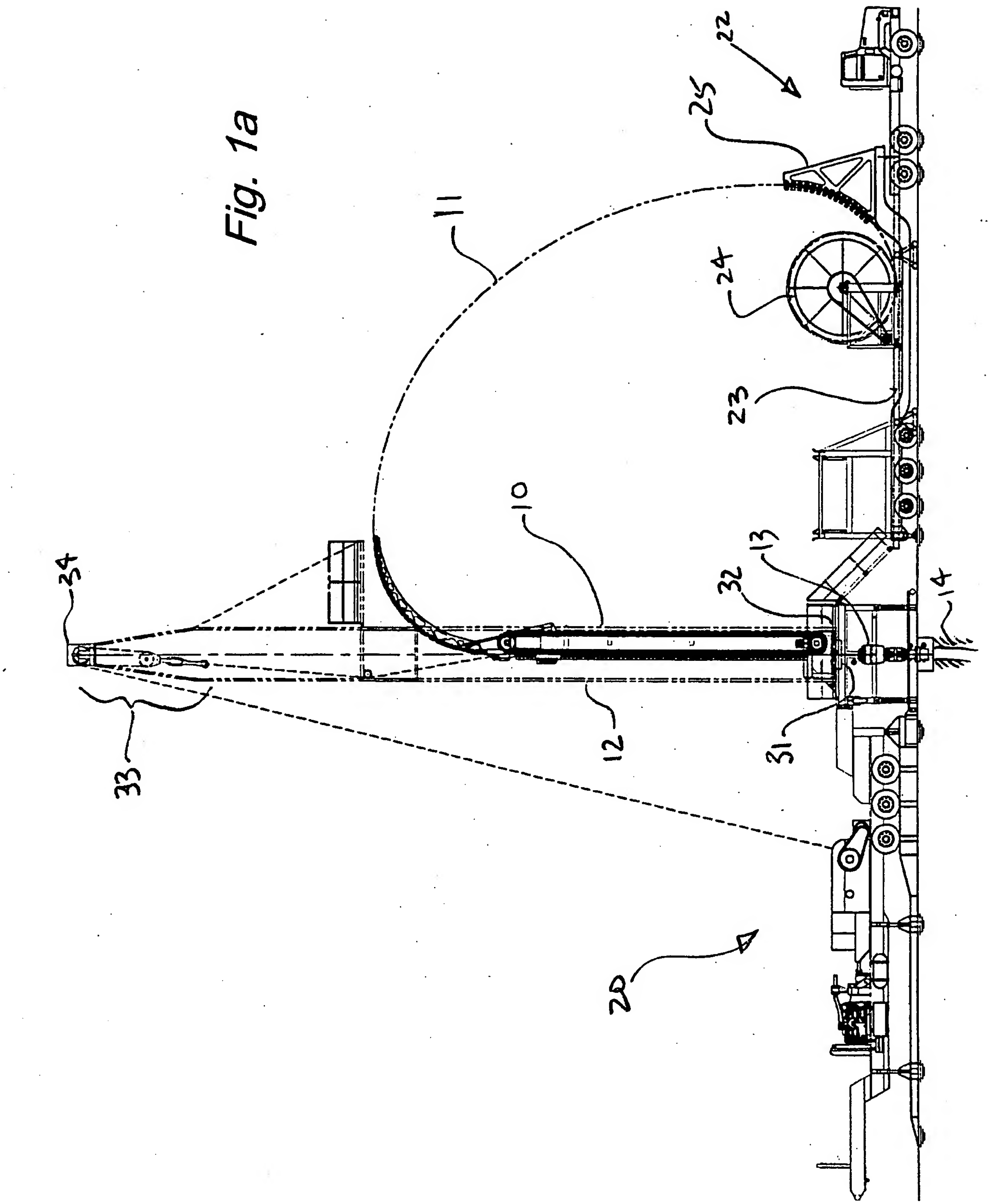
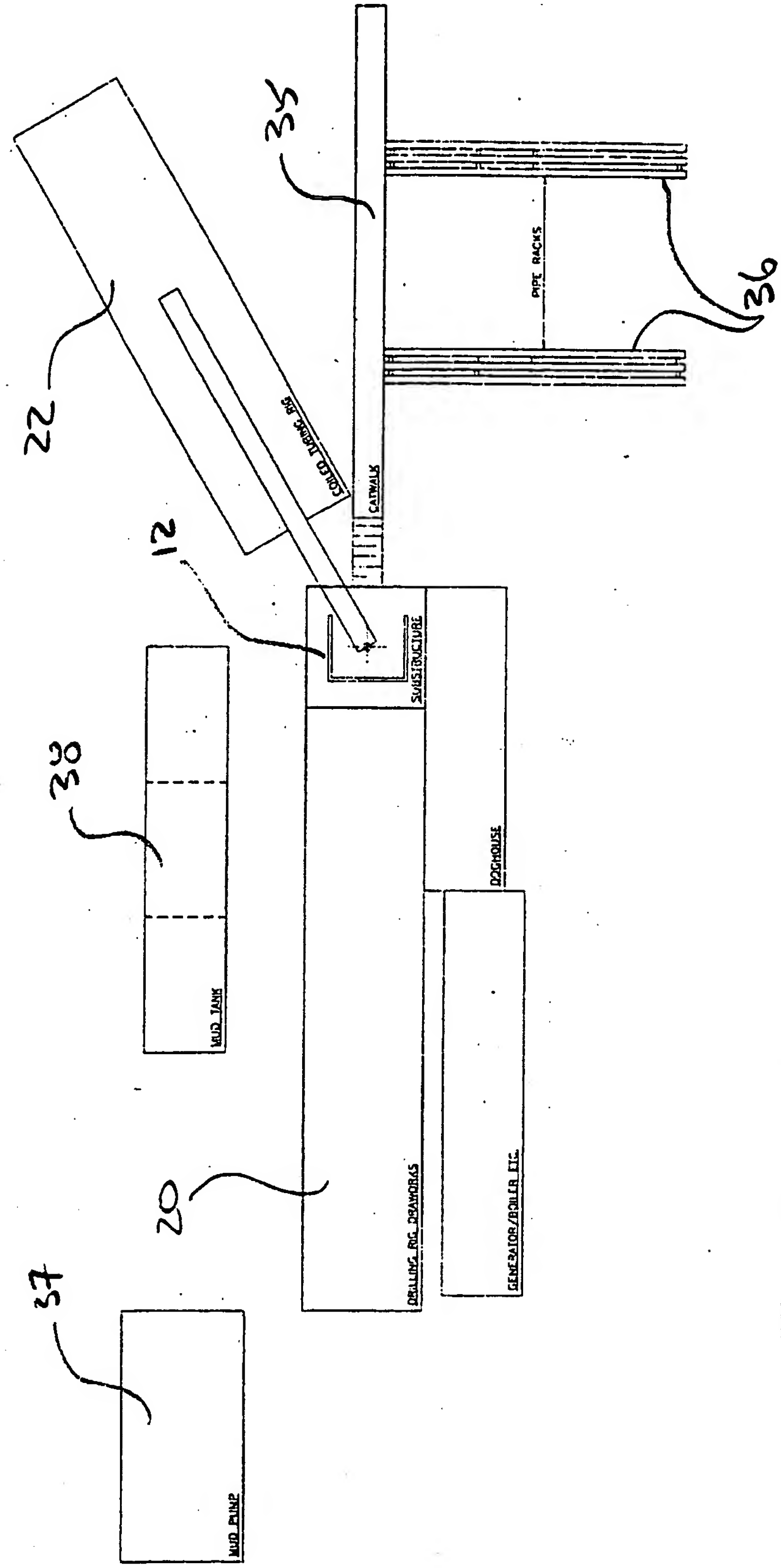


Fig. 1a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COILED TUBING RIG
CATWALK
PIPE RACKS
SUBSTRUCTURE
DOGHOUSE
MUD TANK
DRILLING RIG DRAWORKS
GENERATOR/BOILER ETC.
MUD PUMP

Fig. 1b

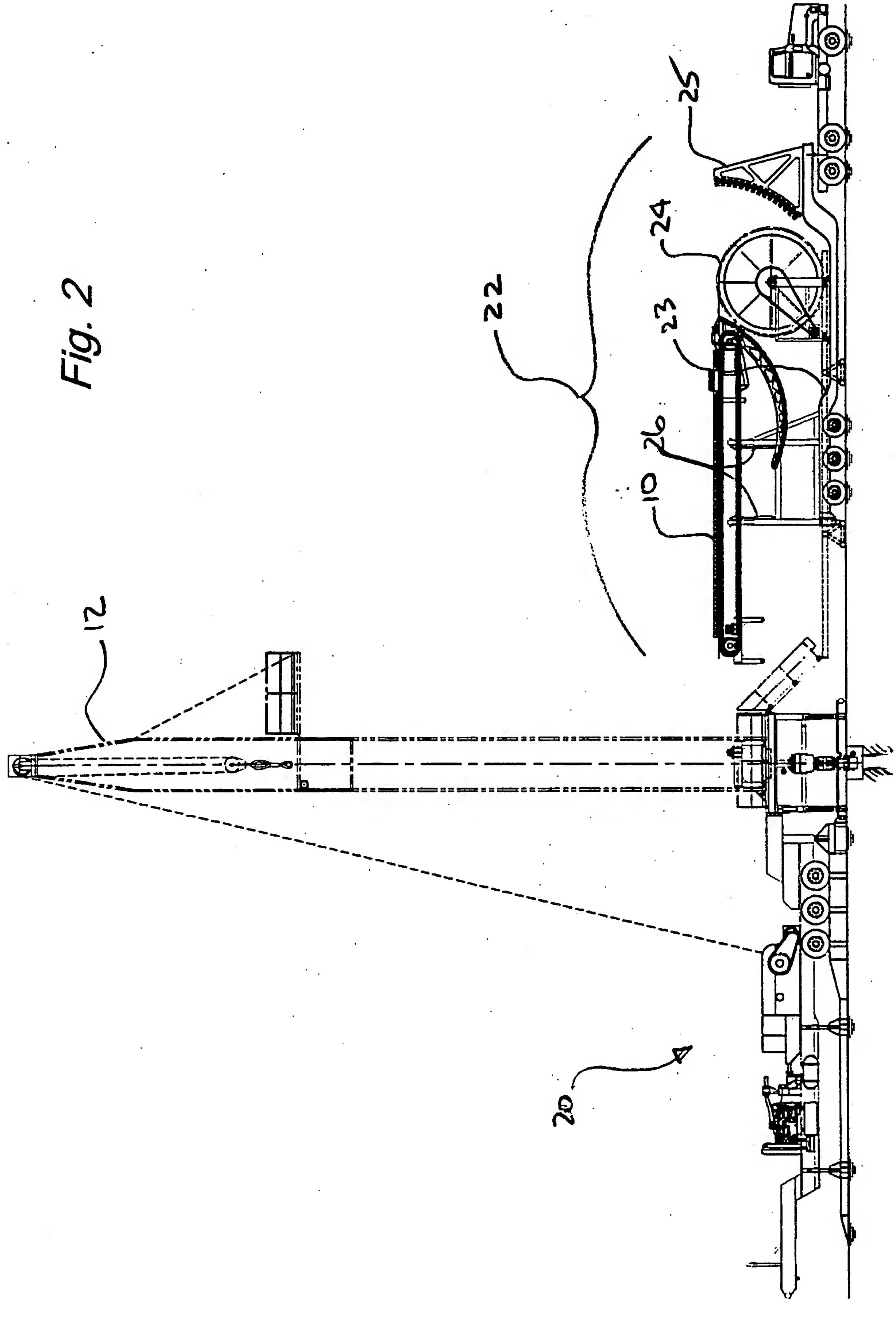


Fig. 2

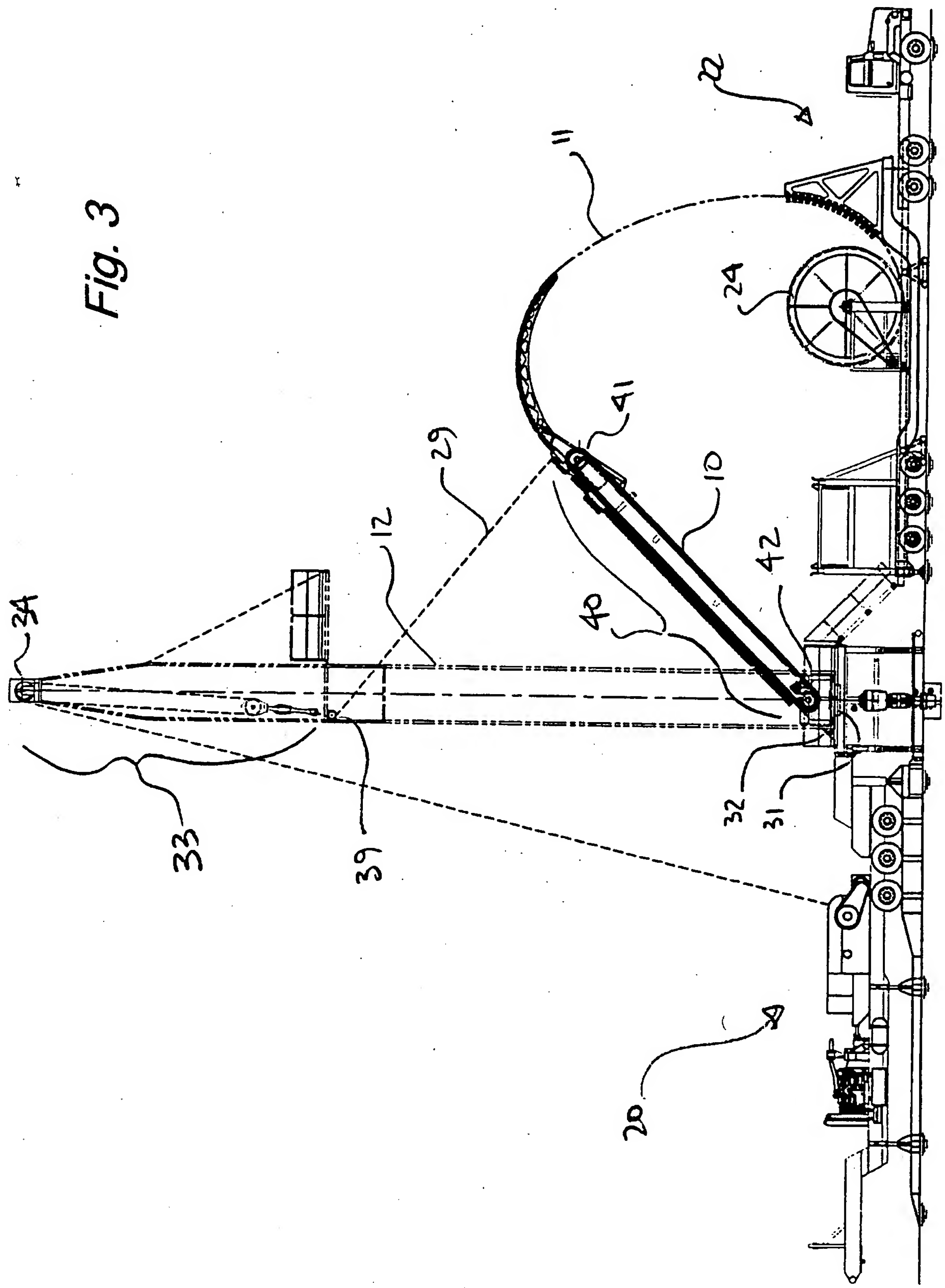


Fig. 3

Fig. 4

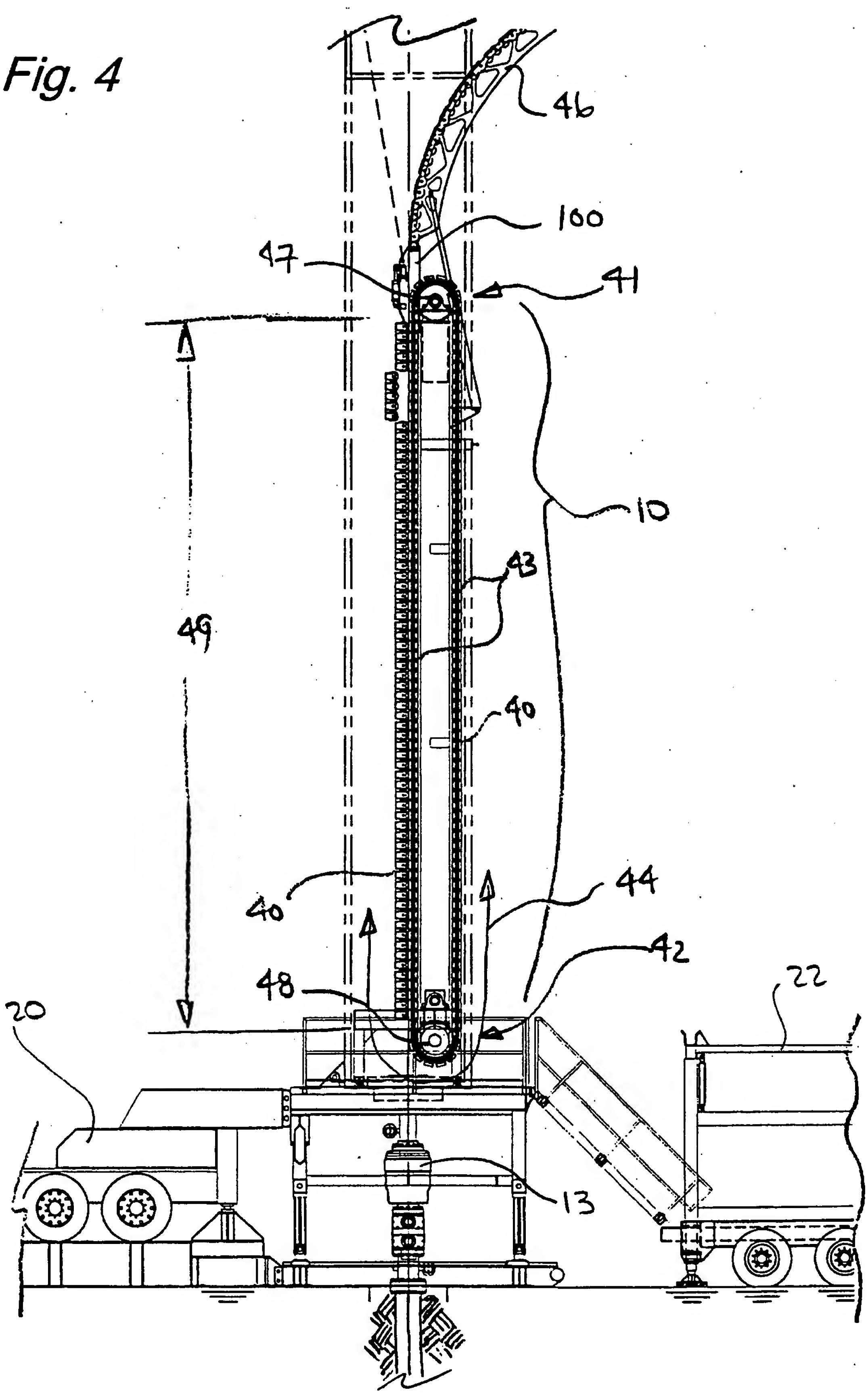
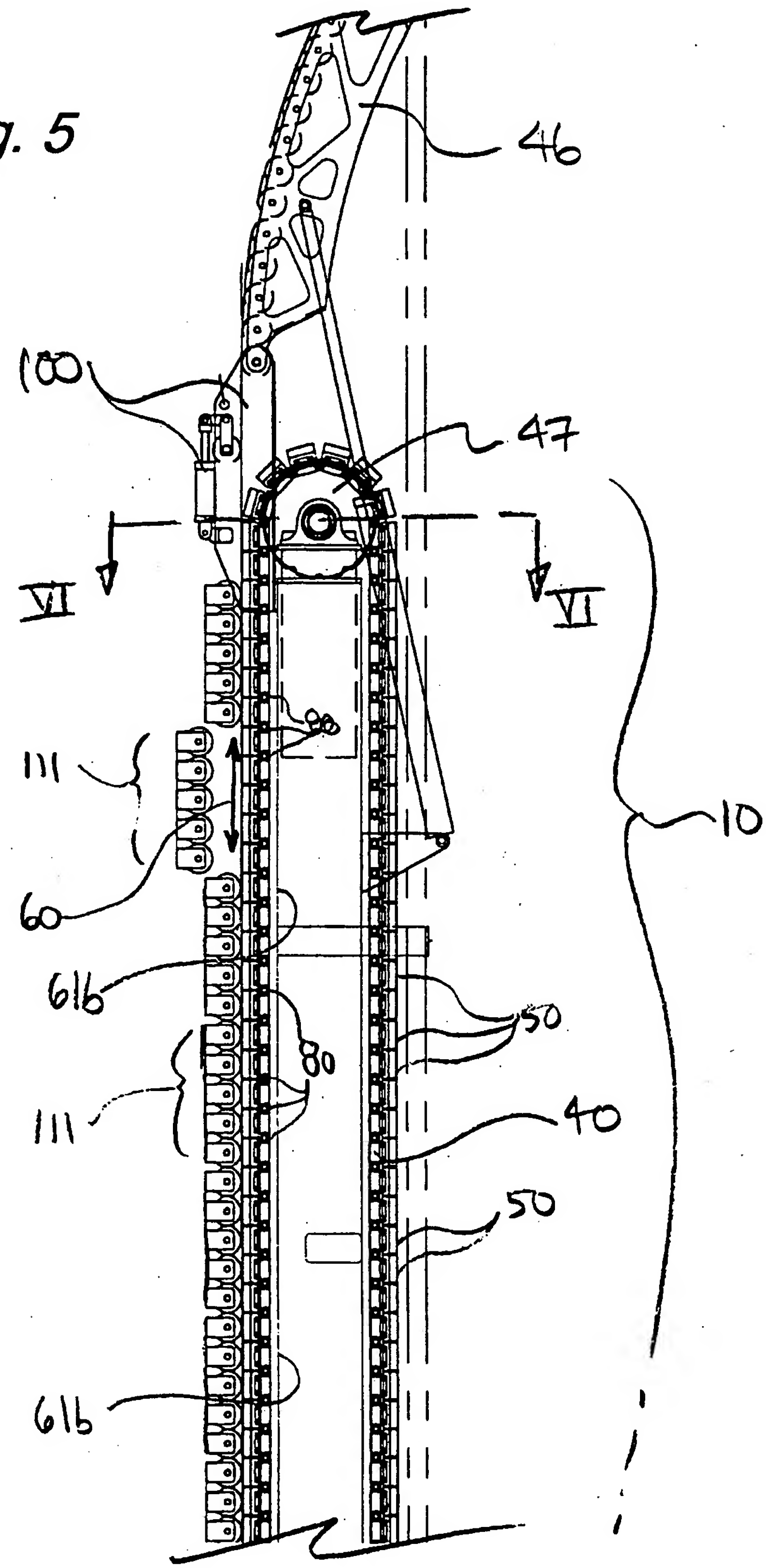


Fig. 5



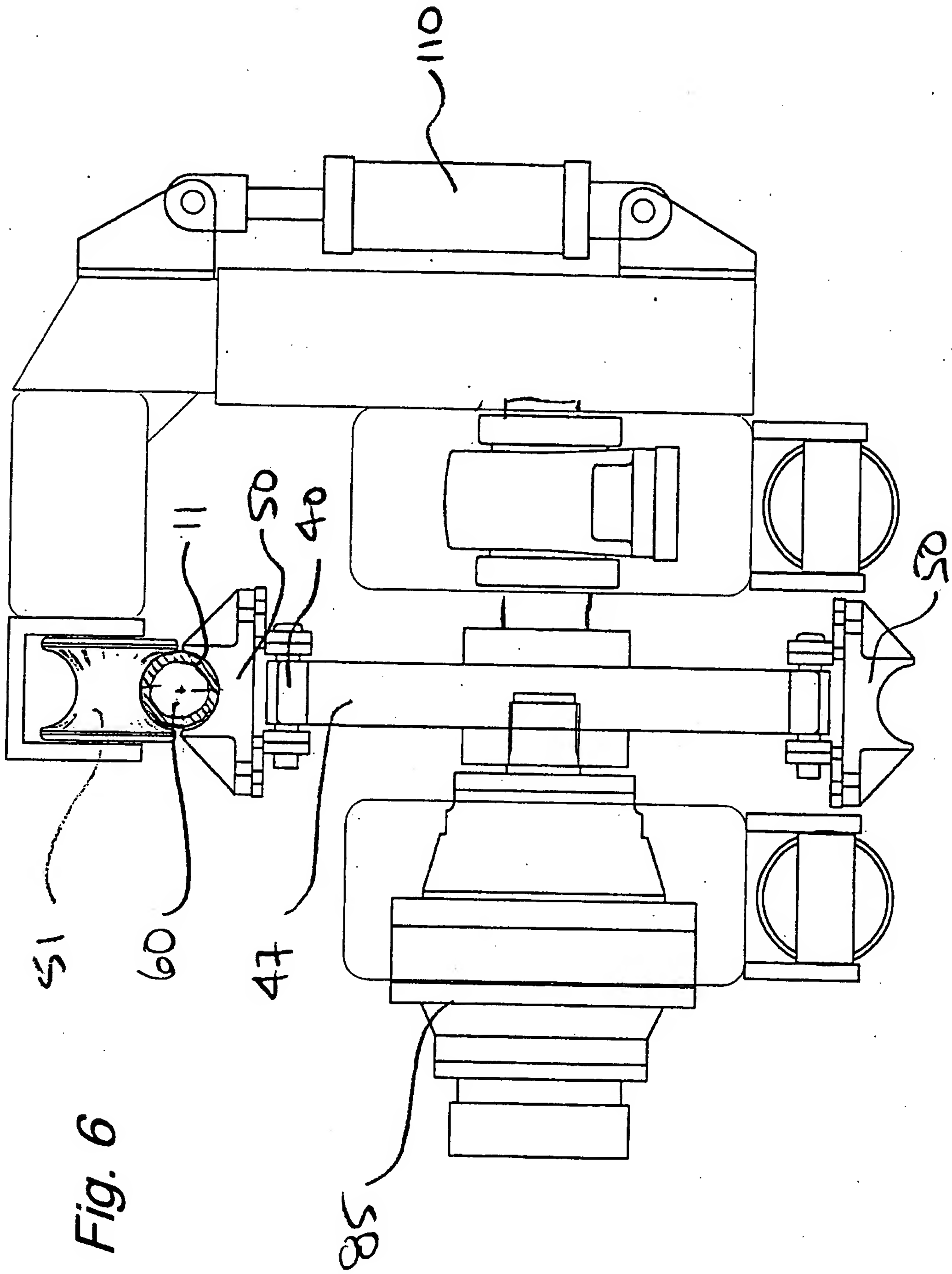


Fig. 6

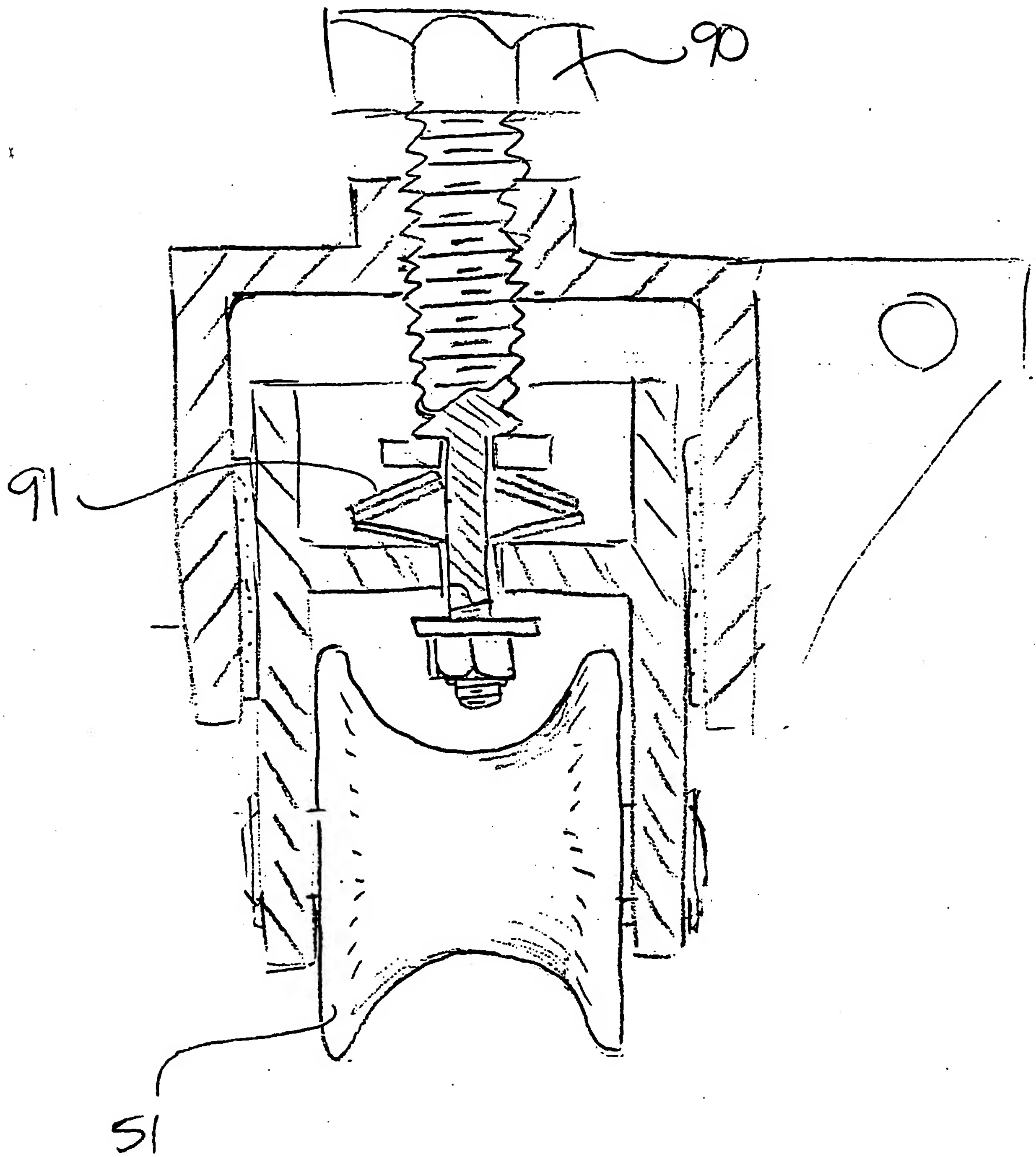


Fig. 7

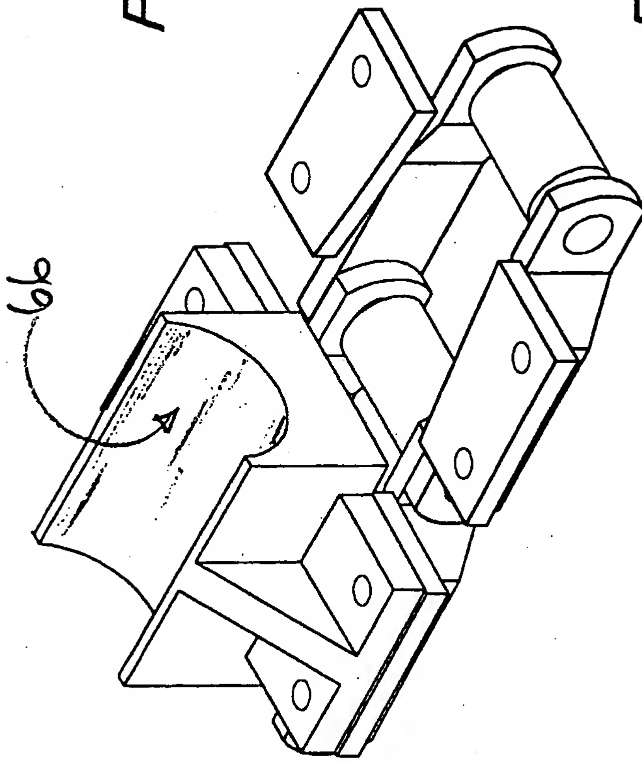


Fig. 8a

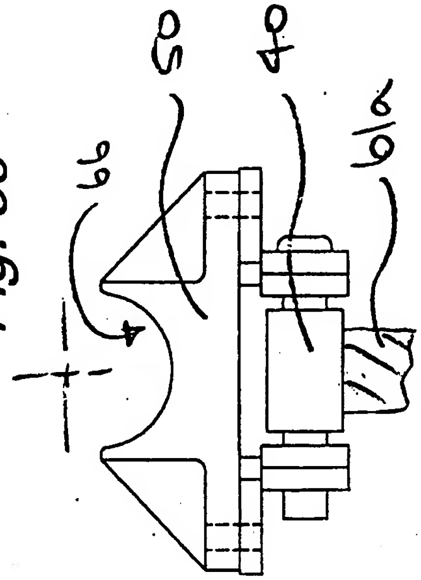


Fig. 8c

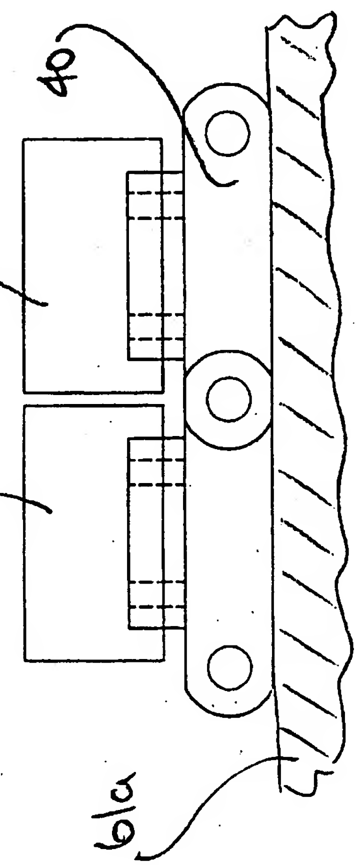


Fig. 8b

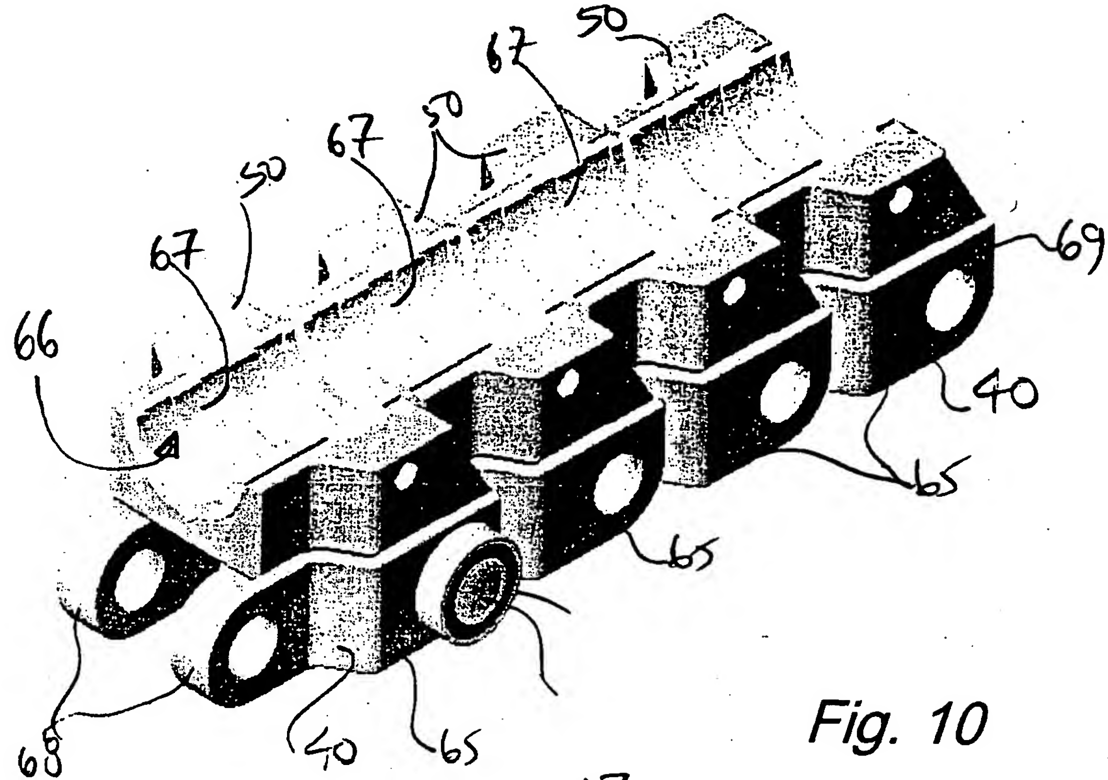


Fig. 10

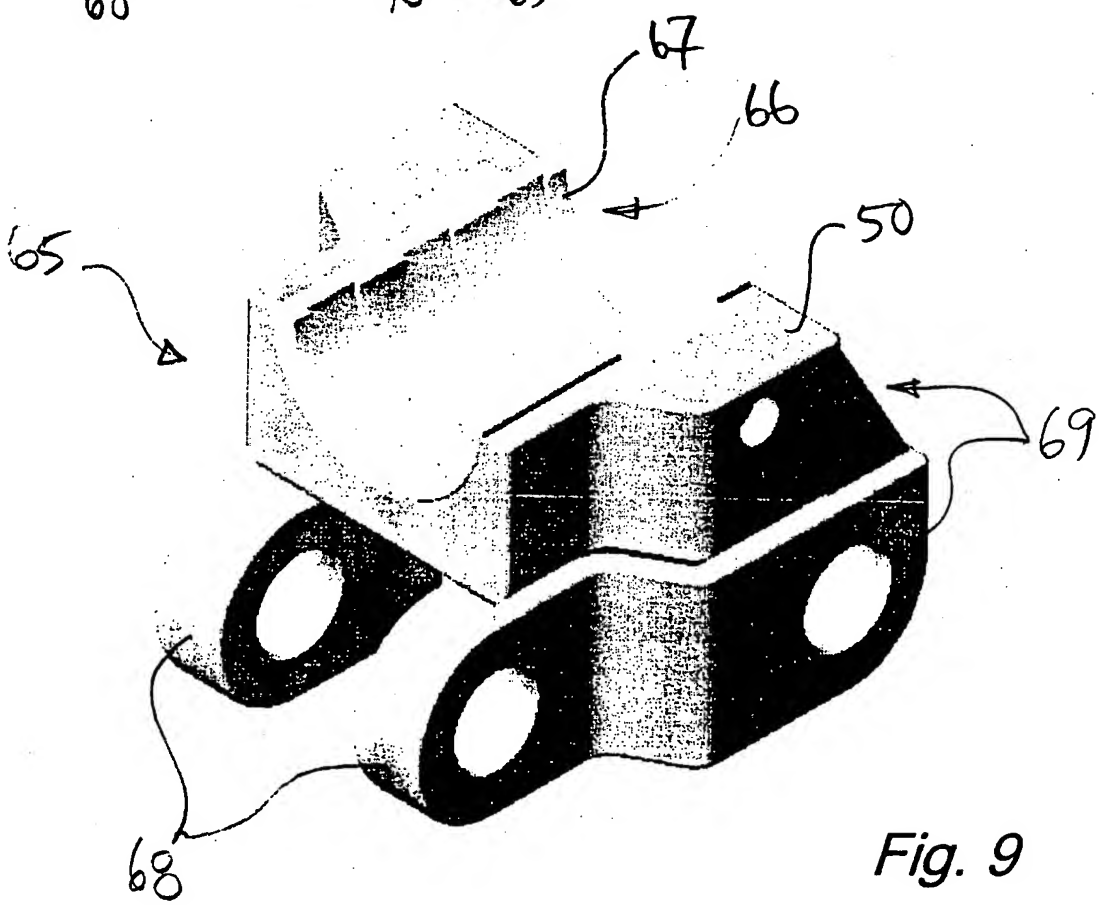


Fig. 9

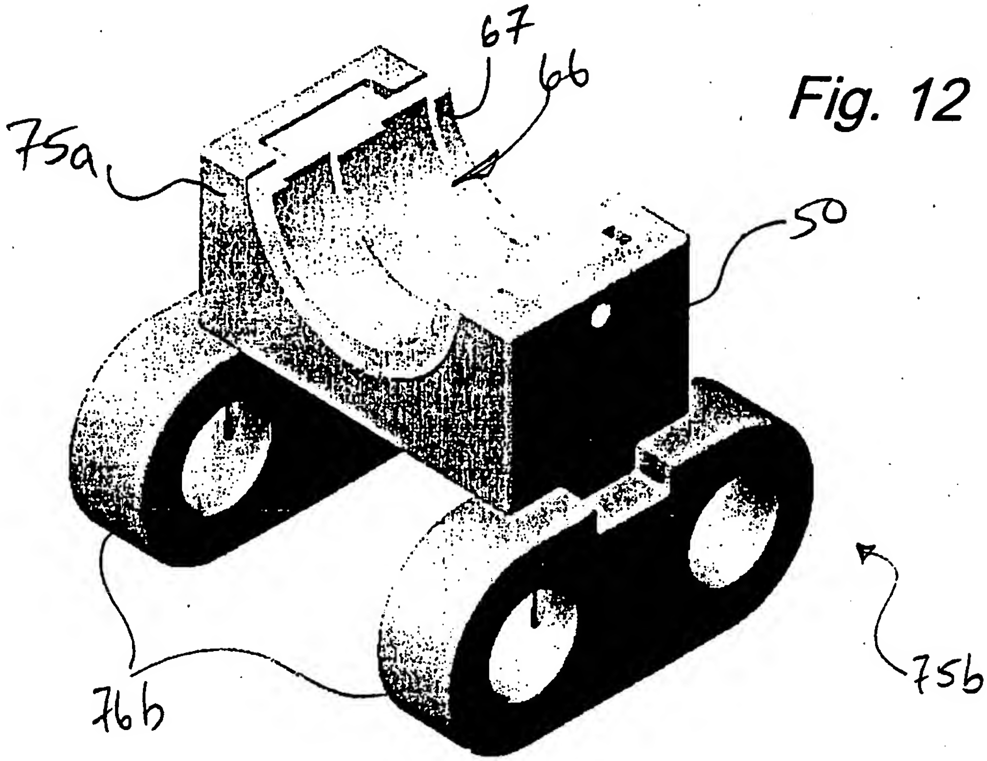


Fig. 12

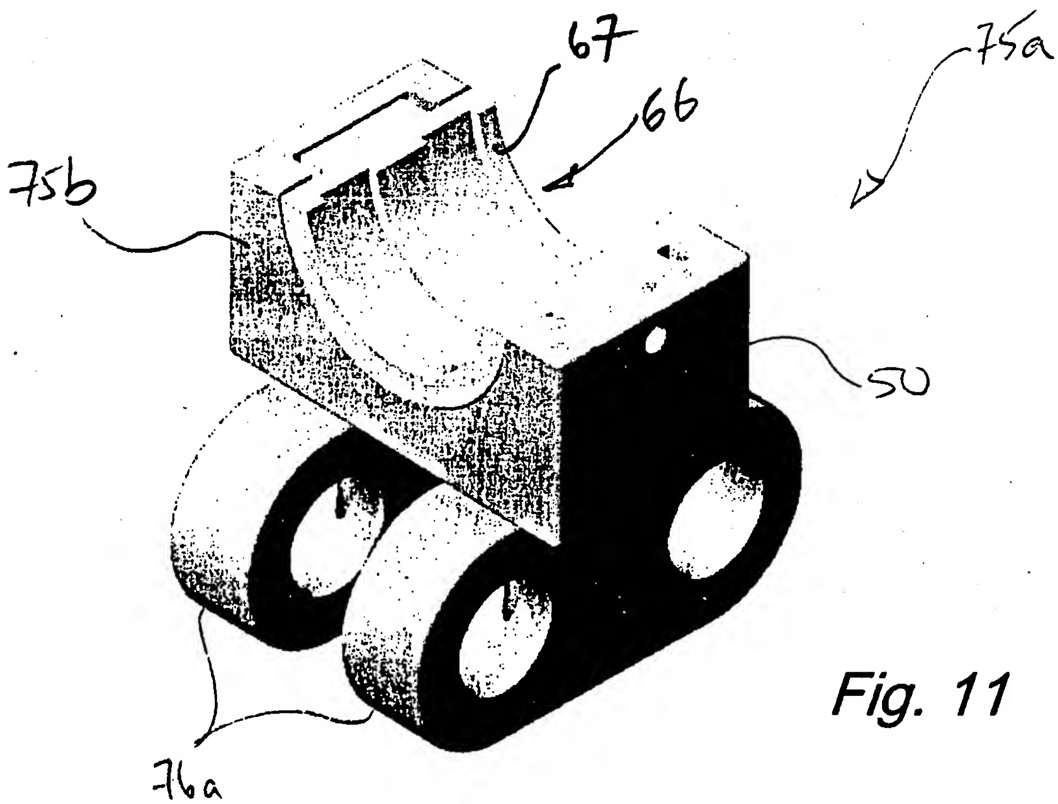


Fig. 11

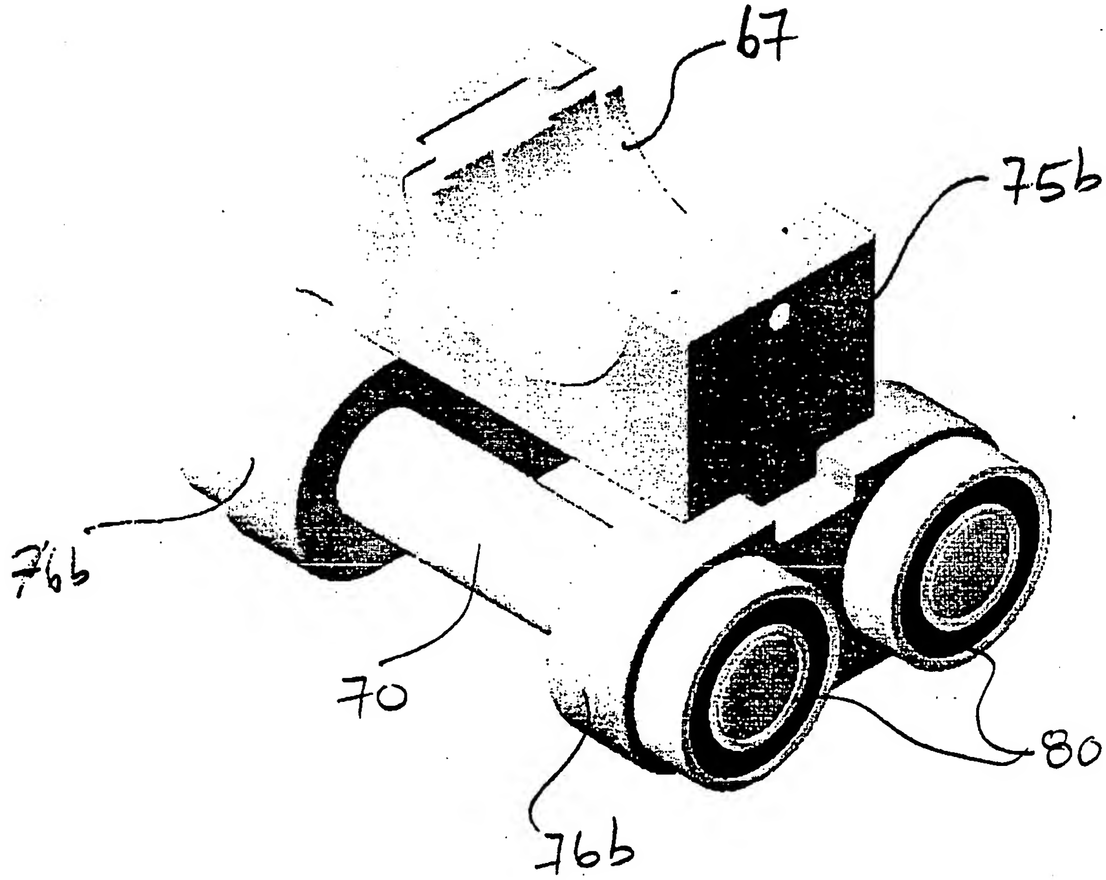


Fig. 13

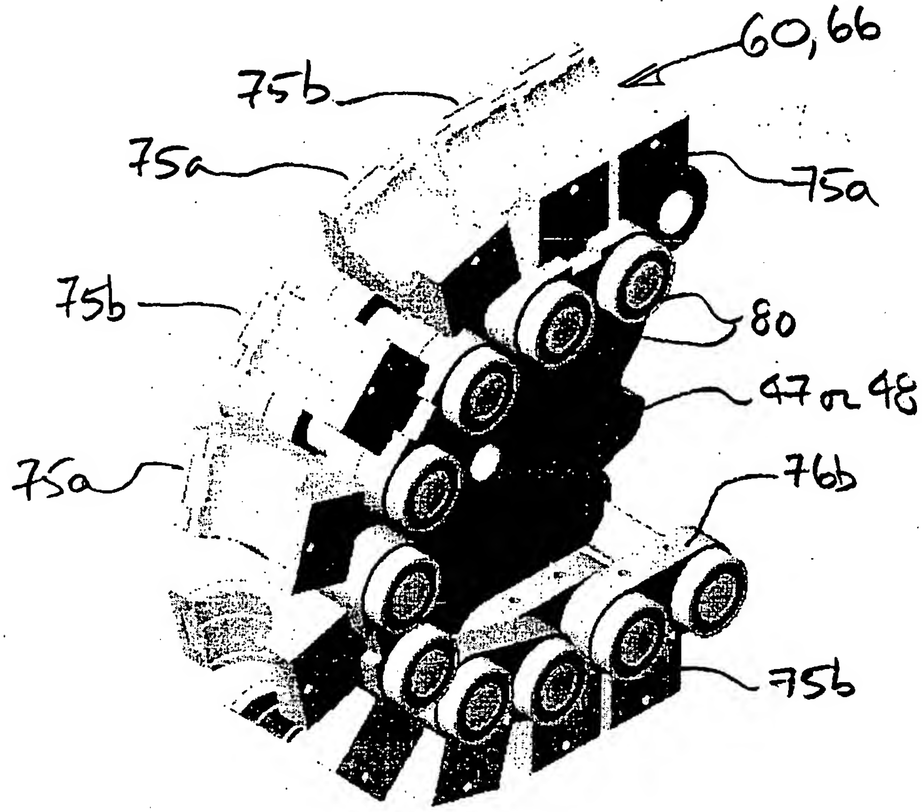


Fig. 14

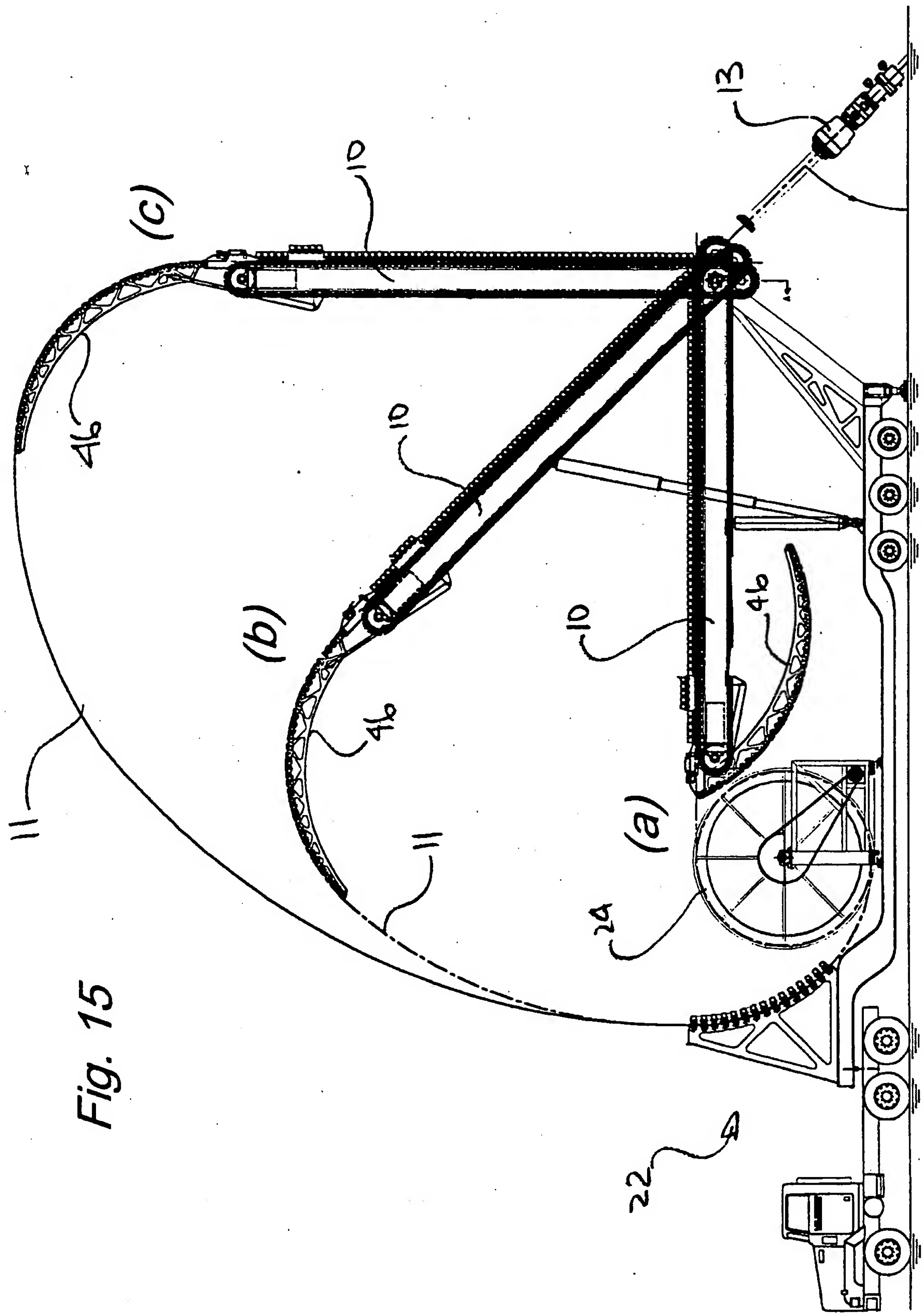


Fig. 15